Challenges in Interconnection and Packaging of Microelectromechanical Systems (MEMS)

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MEMS chip mounting or bonding methods and MEMS chip-substrate interconnection techniques are seriously considered in MEMS packaging (which includes stress decoupling, chemical passivation, electrical shielding and interconnections). MEMS active elements are in direct contact with environmental physical and chemical parameters, which degrade the reliability of the overall package. MEMS have shown significant promise in the last decade for a variety of applications such as sensors for air-bag deployment (accelerometers), pressure sensors, accelerometers, microgyros, chemical sensors, artificial nose, etc. Standard semiconductor microelectronics packaging protects the integrated circuits (IC) from the harsh environment, provides electrical communication with the other parts of the circuit, facilitates thermal dissipation efficiently, and imparts mechanical strength to the silicon die. Microelectronics packaging involves wafer dicing, bonding, lead attachment/interconnects, encapsulation to protect from the environment, electrical integrity, and package leak tests to assure reliable IC packaging and interconnect technology.

Applications of MEMS sensors and their packaging technology have been under rapid development in the last decade or so. Thick and thin film technology can be used to produce an electronic circuit for sensor adjustment, (nulling, offset, calibrating sensitivity) temperature compensation and signal processing. The MEMS package includes a MEMS device and a signal conditioning electronic circuit. The electrical signal from the MEMS sensors is mainly low level, and therefore, very sensitive to some kind of interference. The electronic circuit has significant influence on the accuracy and long term stability of the MEMS package.

Active elements or microstructures in MEMS devices often interface with the hostile environment where package leak tests and testing of such devices using chemical and mechanical parameters will be very difficult and expensive. Packaging of MEMS is complex as the package protects the device from the environment and the microstructures must still interact with the same environment to measure or affect the desired physical or chemical parameters. Most of the silicon circuitry is sensitive to temperature, moisture, magnetic field, light, and electromagnetic interference. The package must then protect the on-board silicon circuitry while simultaneously exposing the microsensor to the effect it measures.

MEMS technology has major applications in developing microspacecraft for space systems provided the reliability of MEMS packaging/interconnect technology is sufficiently addressed. This MEMS technology would eventually miniaturize many of the components of the spacecraft to reach the NASA's goal of building faster, cheaper, better, safer, smaller, and more reliable spacecraft to explore space more economically and effectively.

One of the methods used is to create through wafer vias that allow access to each of the active signal lines on the device wafer. These vias can then be connected to a metal line that runs to a bond pad at the periphery of the MEMS chip. The pad is then wire bonded or solder bumped, to allow one to use a flip chip attachment of the MEMS die to a package substrate. The viable option for fabricating through wafer vias in a high volume-manufacturing environment is bulk micromachining. These vias will consume a fairly large portion of the available silicon real estate. For low I/O count devices, this requirement can be managed, however, for more sophisticated sensors or multi-sensor systems, this option may become a technical challenge.

Hermetically sealed packages require that the active signal lines travel through the seal region to make electrical connection to the device. This can require additional processing, which increases the cost and complexity of the sensor. Conventional single MEMS-chip packaging frequently limits the over all density and performance of MEMS systems. These limitations may be overcome by a variety of customized multi-MEMS chip-packaging approaches that provide short and dense chip-to-chip to interconnections. The challenge to the MEMS sensor manufacturer is to develop packaging technologies that meet all the necessary performance and reliability criteria while keeping assembly costs to a minimum. In the case of MEMS, the packaging needs to be considered very early in the design cycle, and adequate consideration must be given to the end use environmental conditions in which MEMS will be placed. Single MEMS chip packaging approaches and their limitations in the packaging of high performance MEMS will be reviewed in this presentation.

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